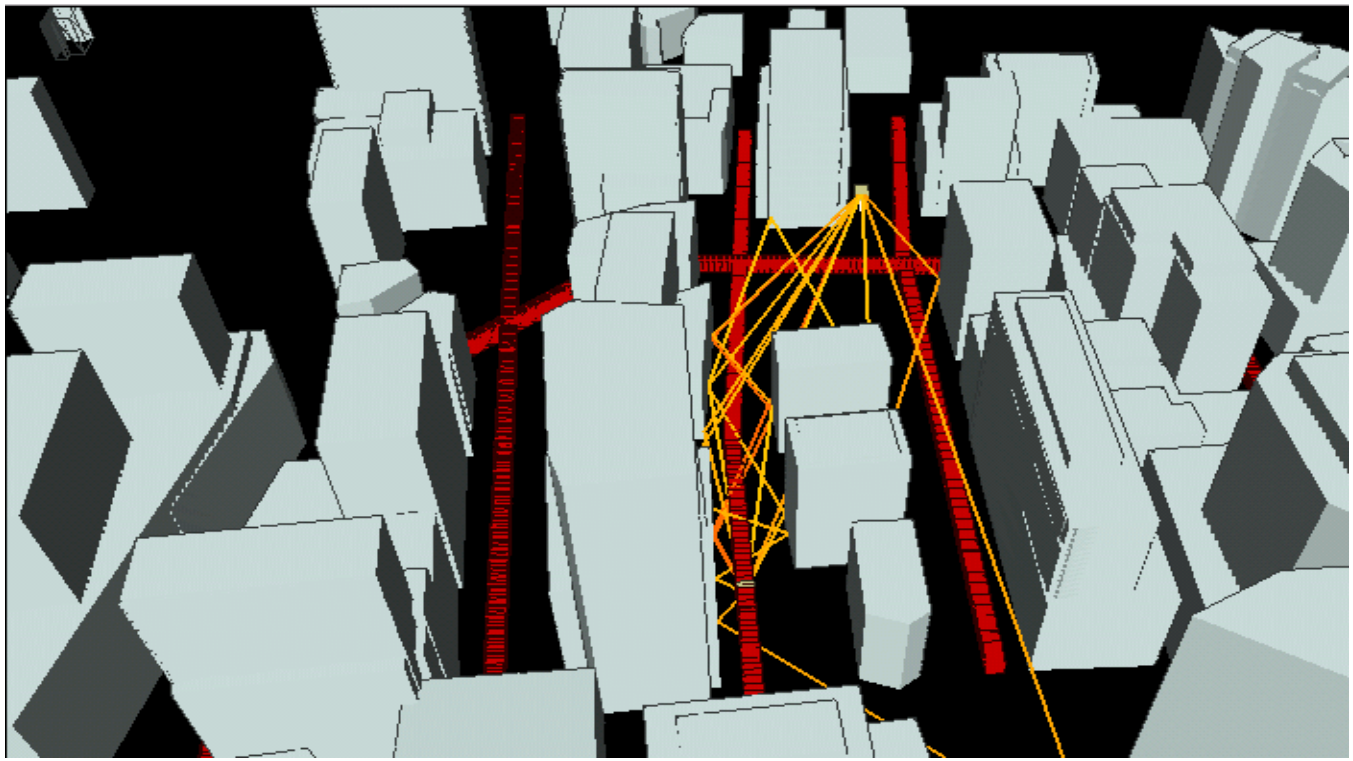
AMSAA MOUT RF Propagation Model



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Outline

Background: Previous work

Overview of this effort

More details regarding the integrated product

Questions for combat model developers

Background: Work leading up to this project

Problem: Identify deficiencies of current tactical communications models as they are extended to an urban environment and formulate a plan to remedy them

- **Primary deficiency is modeling RF propagation– predicting link path loss**
  - -- Current propagation models cannot account for multipath effects
  - -- There is no way to simply extend these models to an urban environment
- **Alternative new approaches considered were FDTD, SBR/GTD, and empirical models**

1. Empirical Models
   - -- Insufficient accuracy and precision, though very fast
   - -- Predictions are independent of building layout, so models are unlikely to be improved
   - -- Can't take directional antennas into account
   - -- Unsuitable for indoor and indoor/outdoor links
2. Finite Difference Time Domain (FDTD)
   - -- Accurate, but with large processing requirements
   - -- Maximal region processed is about a 100 wavelength cube
   - -- This corresponds to a linear dimension of about 20 m at 2.5 GHz
3. SBR/GTD
   - -- Physics-based model– potential for high accuracy
   - -- Can model indoor, outdoor, indoor/outdoor links, & directional antennas
   - -- Large processor requirements, but not unreasonable like FDTD

- **Alternatives were compared using existing validation data**
  - -- Existing path loss data collected by AT&T Bell labs at 900 & 1900 MHz in Rosslyn, VA was used as the basis for model performance comparison– over 50,000 links
  - -- SBR/GTD models compared were from Remcom Inc., Schafer Wireless, and EMAG Technologies

Conclusions of our preliminary work

1. **The EMAG technologies model is the best available propagation kernel for a near term solution**

   • Prediction performance is much better than that of the other models
   • Causes of the significant prediction errors of this model are understood and can be addressed using ideas appearing recently in the technical literature
   • Ongoing efforts from several DOD agencies aimed at code parallelization and improving the user interface in an HPC environment can be leveraged
   • No alternative approaches can satisfactorily address system performance or small unit force effectiveness modeling requirements

2. **Empirical models may be the best alternative in the short term for force effectiv models**

   • Prediction performance for outdoor links is better than would be expected
   • Runtime is fast compared to current propagation models

3. **Runtime of SBR/GTD is too great to make them directly applicable to large scale near real time simulations– methodology to integrate with force effectiveness & performance models is critical**

Overview of this effort

This effort has two parts as outlined below:

1. **V&V basic urban propagation model for use in supporting FCS and OF tactical communications decisions**
   - Take outdoor measurements at Rosslyn at additional frequencies to complete validation for a high rise urban area
   - Take indoor, outdoor, indoor/outdoor measurements at sites in Arizona to account for:
     -- buildings of various construction types more typical of those found in developing c
     -- units on various floors inside buildings
     -- ground/UAV links

2. **Develop a methodology whereby the above model can be used both with item le and force on force models**
   - Without incurring a significant runtime increase
   - V&V integrated product

Deliverables

1. Validated basic urban propagation model (3Q FY04)
2. Validated integrated product for generating path loss databases (3Q FY04)
3. Provide sample integrated product to Combat XXI (3Q FY04)

Integrated Product Concept

The integrated product comprises three parts:

1. Methodology allowing user to specify urban environment where path loss prediction are to be made. User selections include
   - -- Boundary of urban region where simulation will occur
   - -- Representative set of ground Tx locations (may be automated)
   - -- Buildings to be entered during simulation
   - -- Rooftop antennas
   - -- Potential air platform locations
   - -- Frequencies to be used
2. Path loss database for this environment

3. Methodology for application interface with the path loss database

Questions for model developers

1. Path loss lookup questions
   Task: User calls database and gets path loss data
   Comments: The basic process is envisioned as follows:
      1. User sends coordinates (r1, r2, f)
      2. These are “rounded” to (R1, R2, F) that appear as records and a field in the databas
      3. R1, R2 are associated with appropriate transmitters T1, T2 and the distances betwe
         are obtained.
      4. Smallest distance is selected as chosen transmitter. Without loss of generality, say, T
      5. The value Loss (T1, R2, F) is returned.

   Questions:
   1. I realize that each user will have their own internal way to do the lookup in real time, but w
   would the most convenient format be for me to provide the data?
   2. What coordinate system is most convenient for the user call?

2. Offline processing– environmental data format
   Tasks: All user selections made during offline processing
   Questions:
   1.Is there a preferred terrain elevation data format (DTED)?
   2. Is there a preferred building data format (Autocad)?

3. Building selection
   Task: Select building(s) to be processed
   Question: It is assumed that users will know beforehand those buildings for which indoor mo
   Is this valid and approximately how many buildings require indoor propagation modeling?

Questions for model developers (contd)

4. Rooftop antenna location
   Task: Select rooftop (Tx) antenna locations
   Question: It is assumed that the user will be able to select a small subset of buildings upon w
   placed, and will know the antenna height and position on the building rooftop. Is this valid?

5. Air platform trajectories
   Task: Select air platform locations
   Questions:
   1. Will users be able to supply trajectories over which air platforms will travel?
   2. If the answer to Q1 is no, then the best we can do is create receiver grids at a few represe
      Which choice of elevations would be appropriate?

General Questions:

6. What size urban area will need to be modeled ?

7. What size limitations would there be on the path loss database?

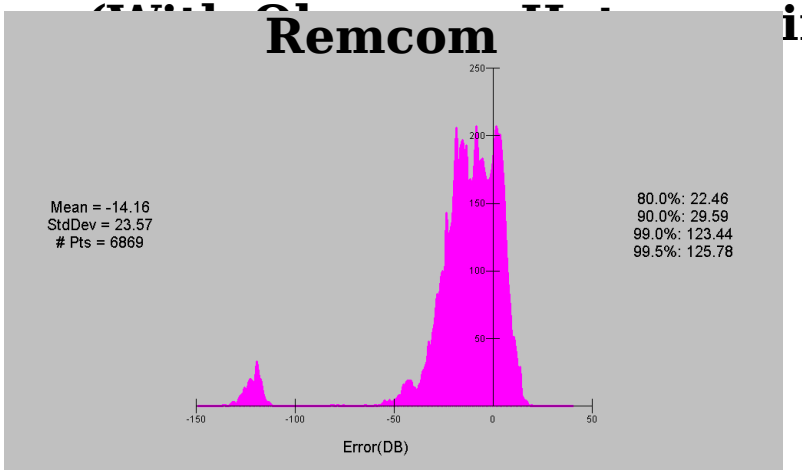
8. What is general approach and required fidelity of communications modeling?

Questions

Results

Overall Results: Fast fading performance at 900 MHz for rooftop Tx

Remcom



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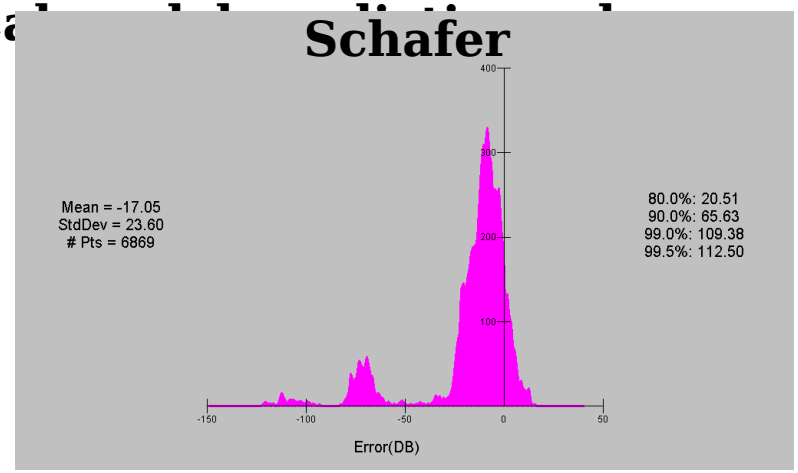

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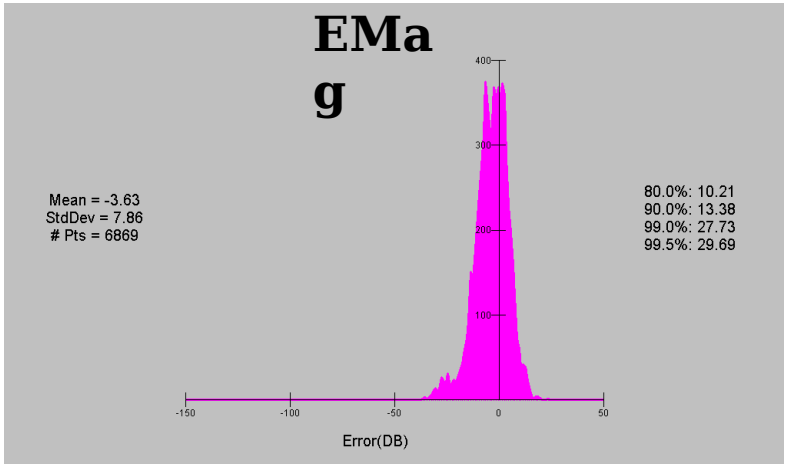

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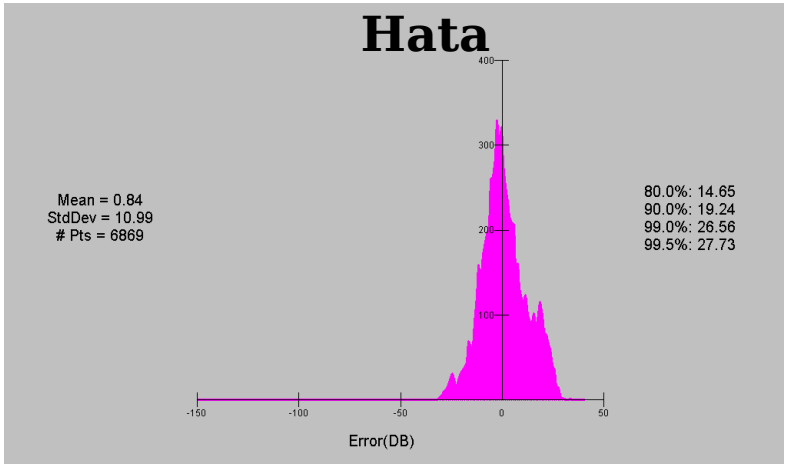
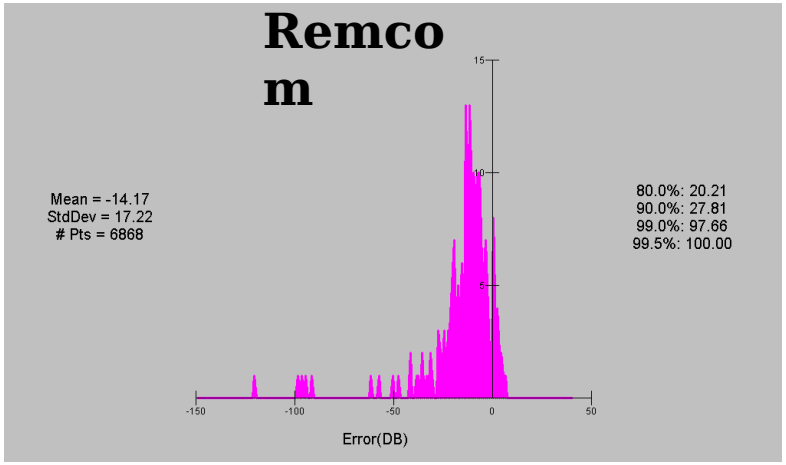


Results

Overall Results: Slow fading performance at 900 MHz for rooftop Tx

Remcom



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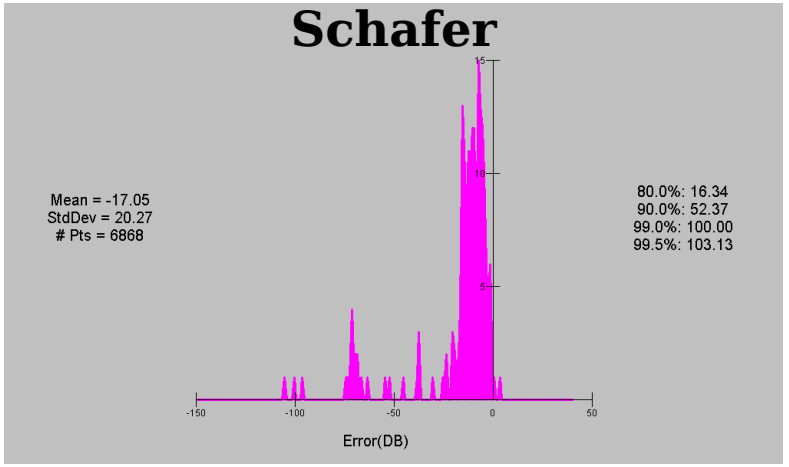

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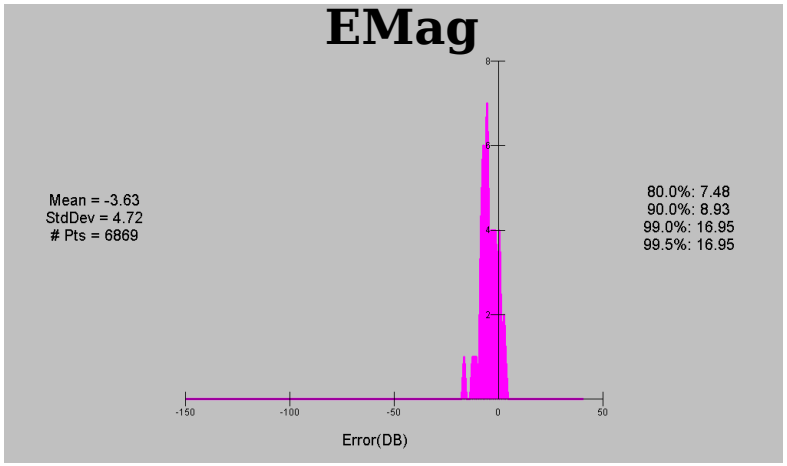

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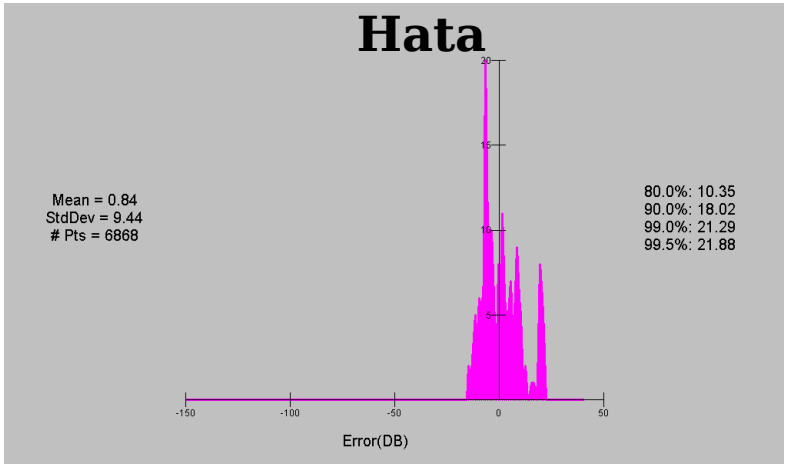

Results

LOS links at 900 MHz for rooftop Tx

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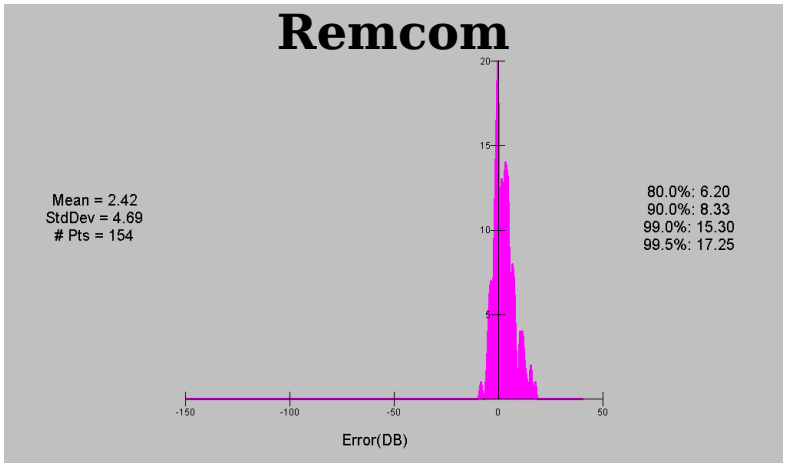

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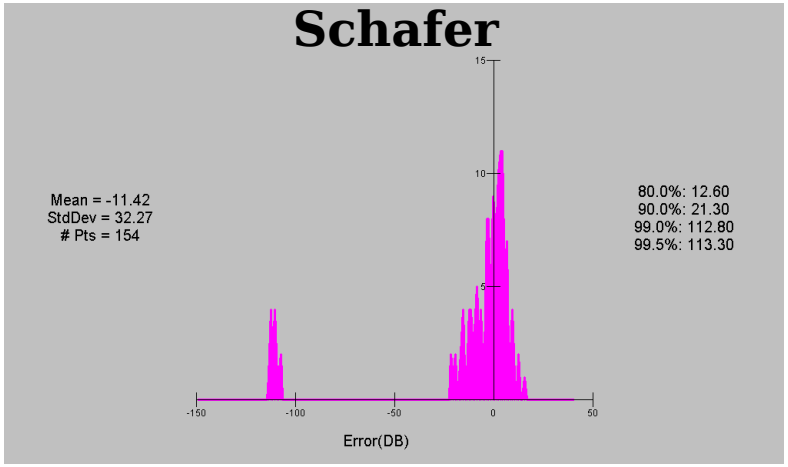

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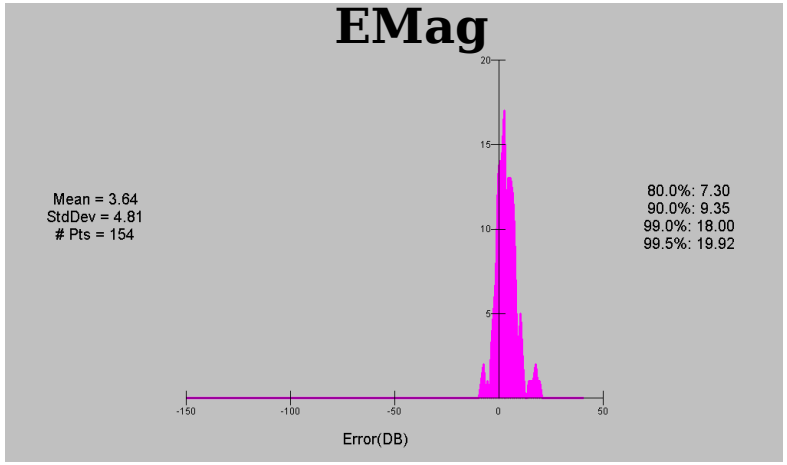

Results

Links dominated by face reflections at 900 MHz for rooftop Tx

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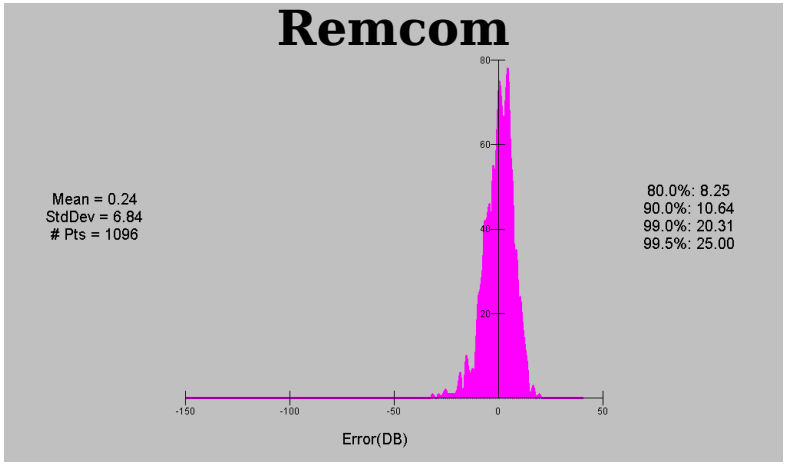

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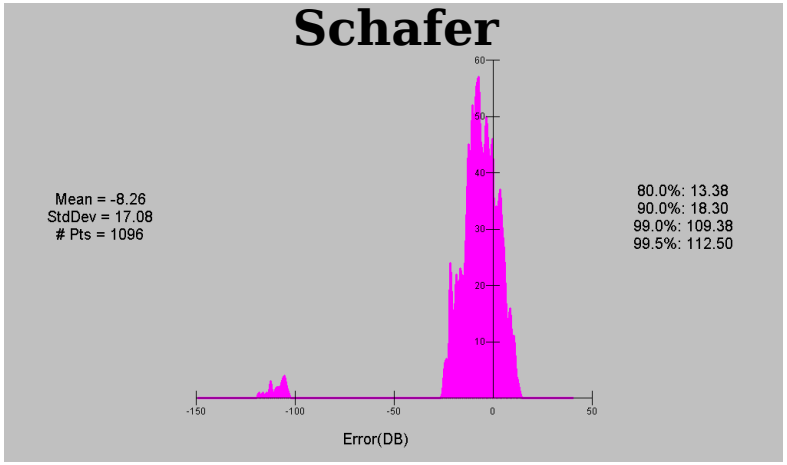

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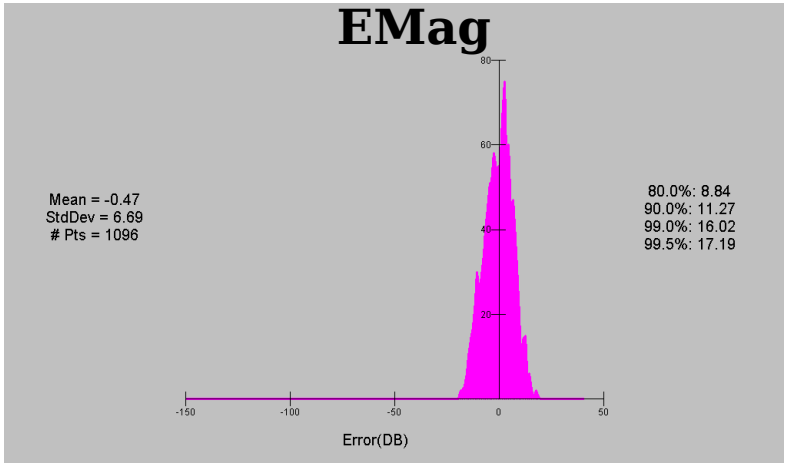

Results

Links dominated by vertical edge diffractions at 900 MHz for rooftop Tx

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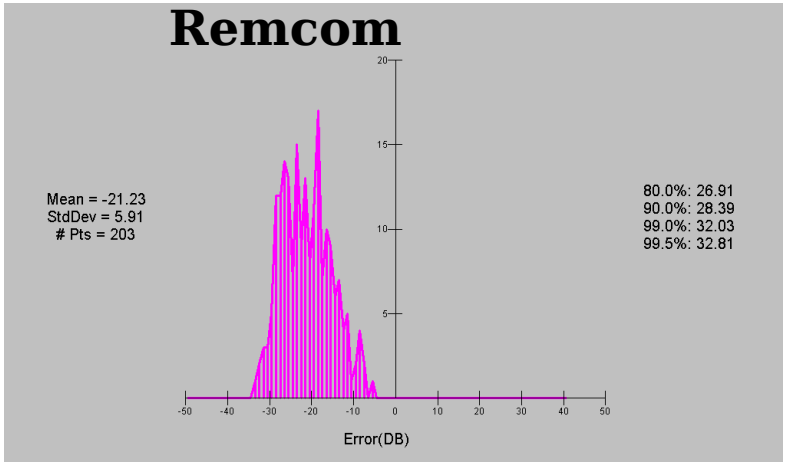

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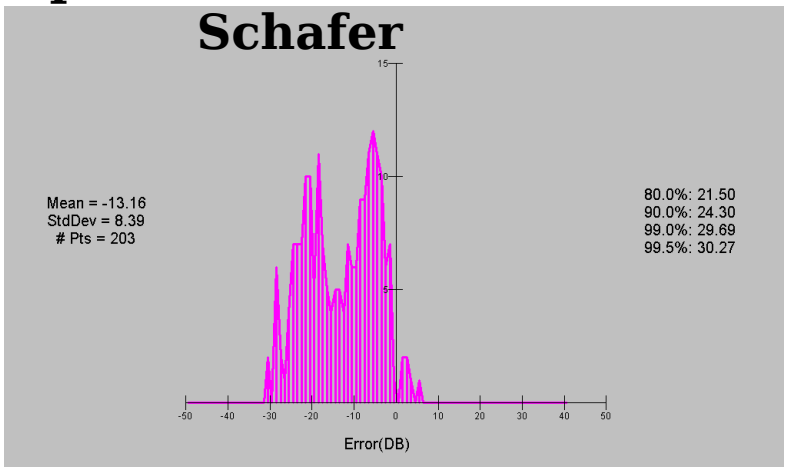

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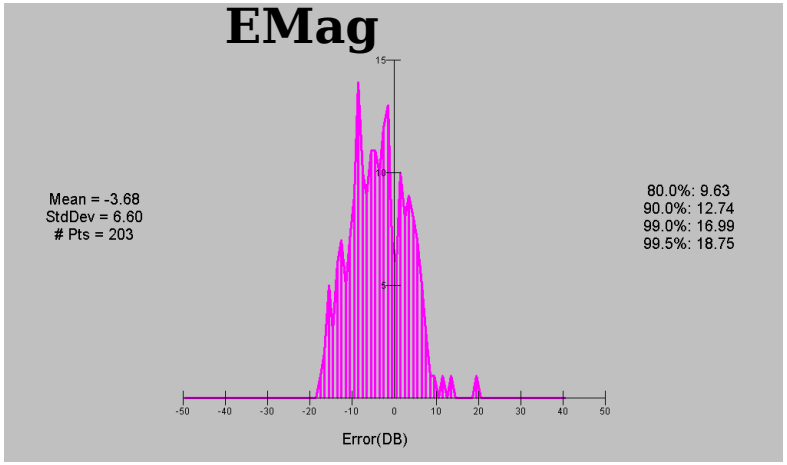

Results

Links dominated by horizontal edge diffractions at 900 MHz for rooftop Tx

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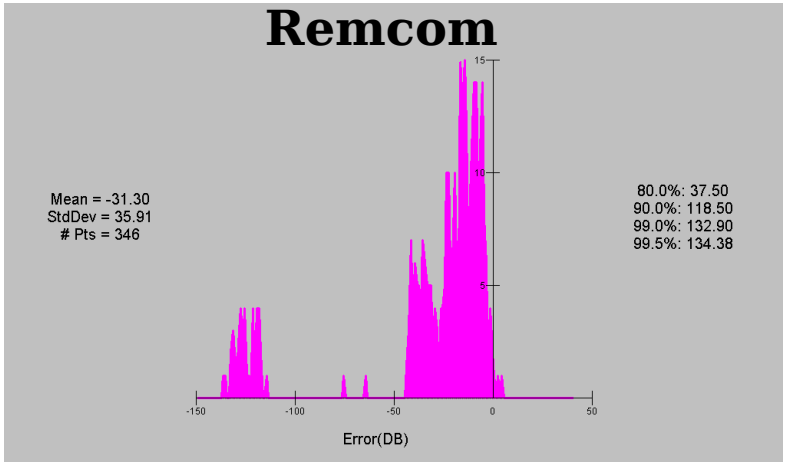

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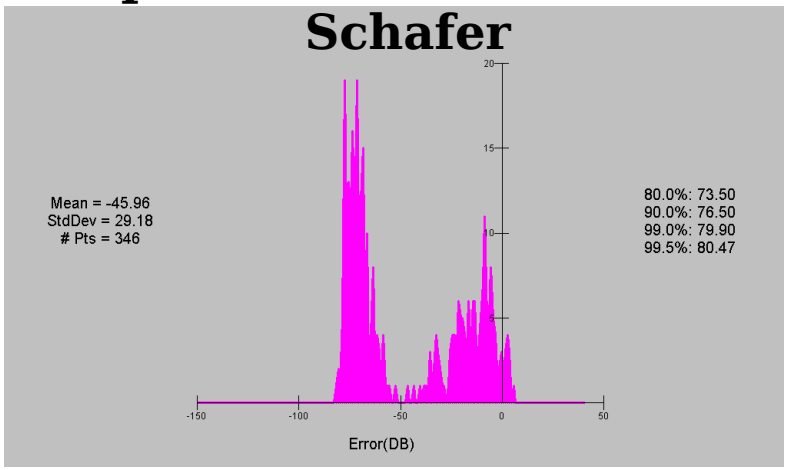

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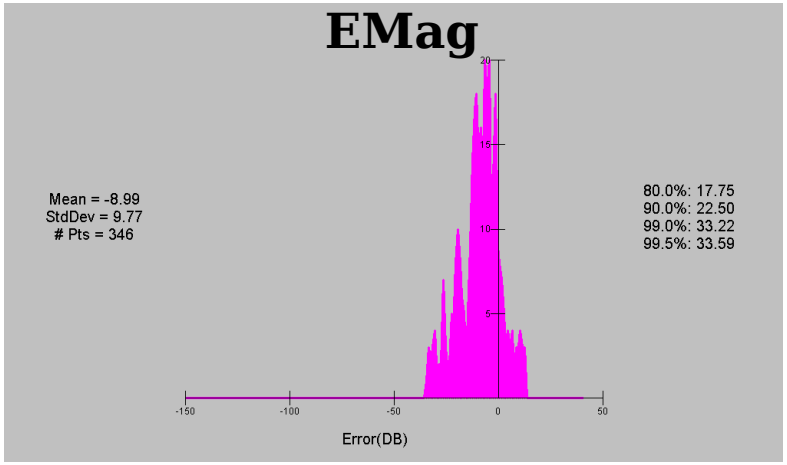

Results

Overall Results: Fast fading performance at 900 MHz for ground Tx

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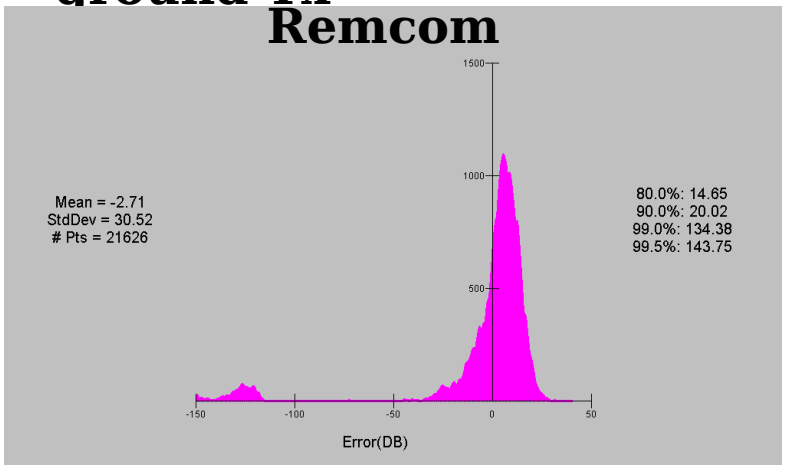

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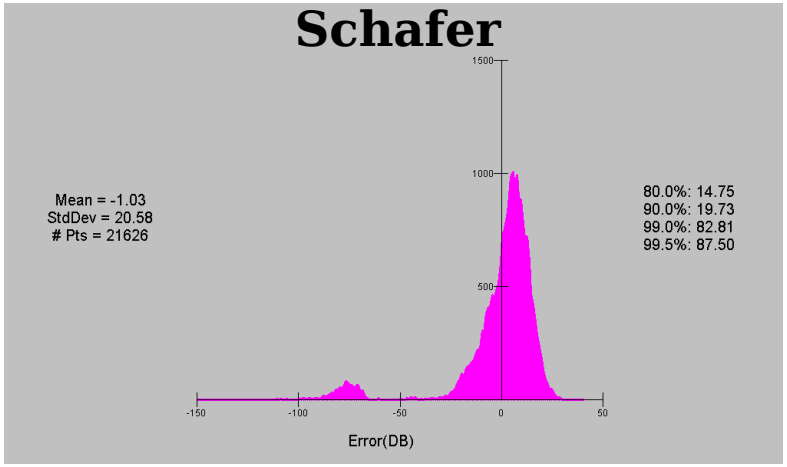

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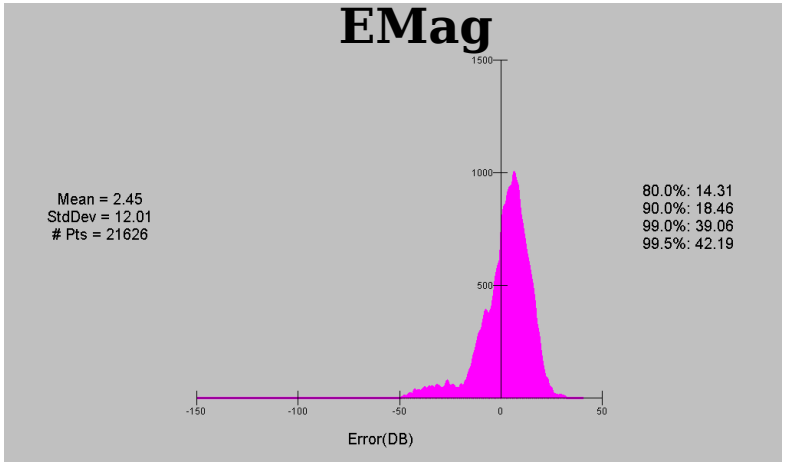

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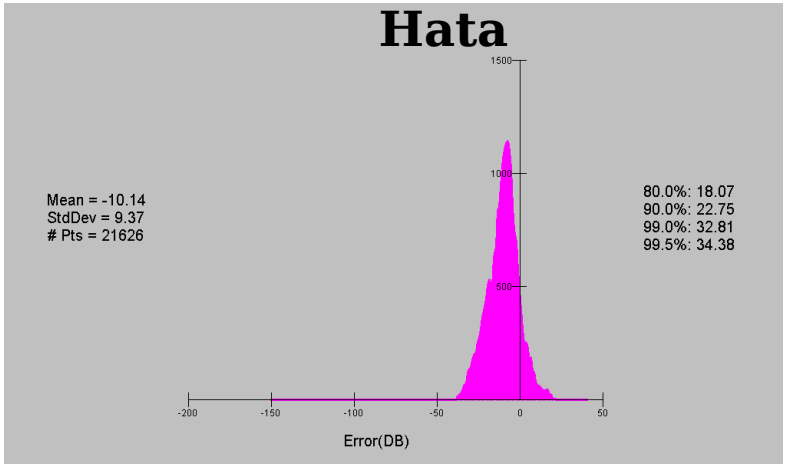

Results

Overall Results: Fast fading performance at 1900 MHz for rooftop Tx

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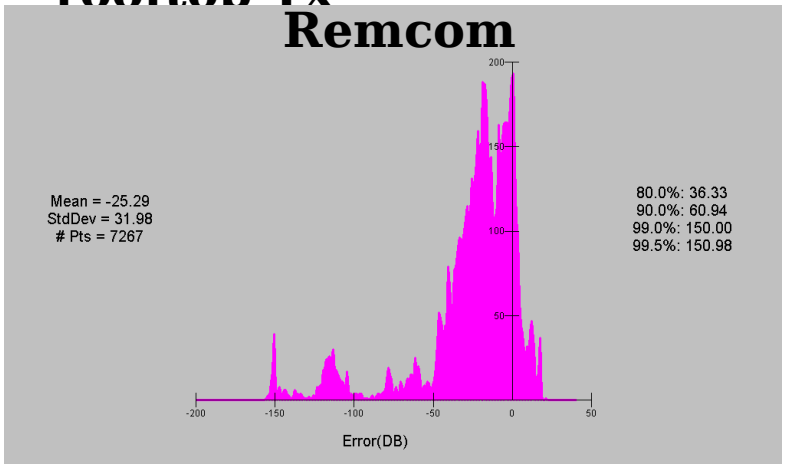

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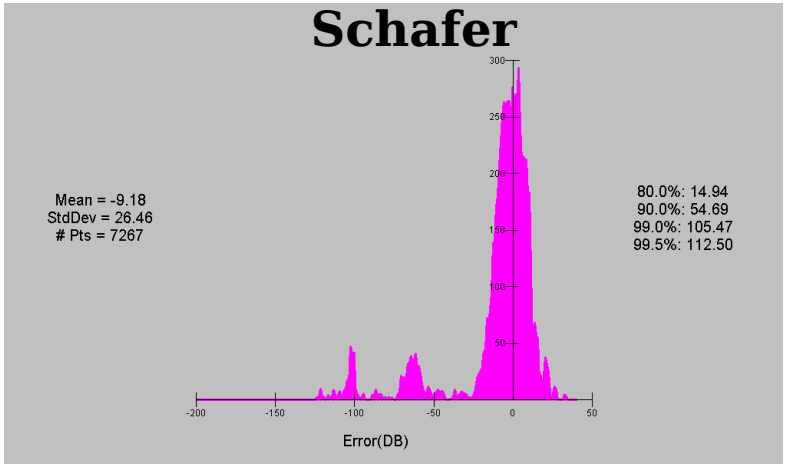

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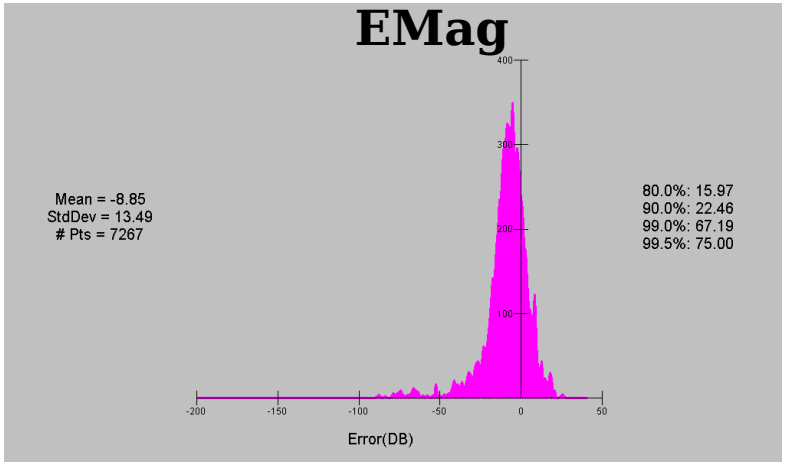

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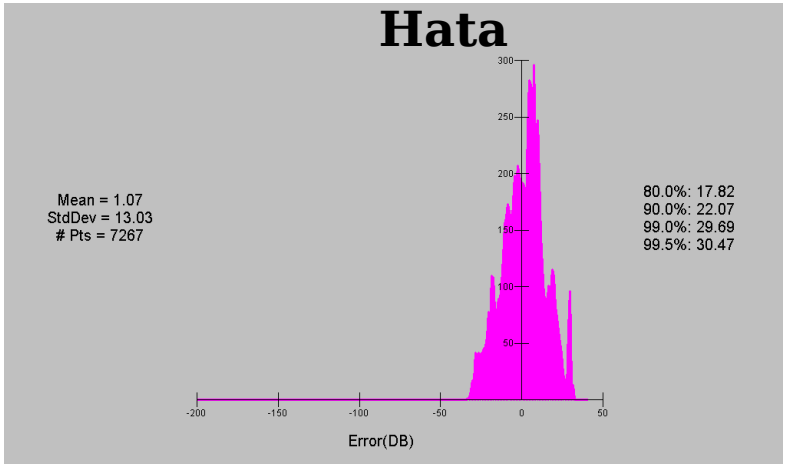

Results

Overall Results: Fast fading performance at 1900 MHz for ground Tx

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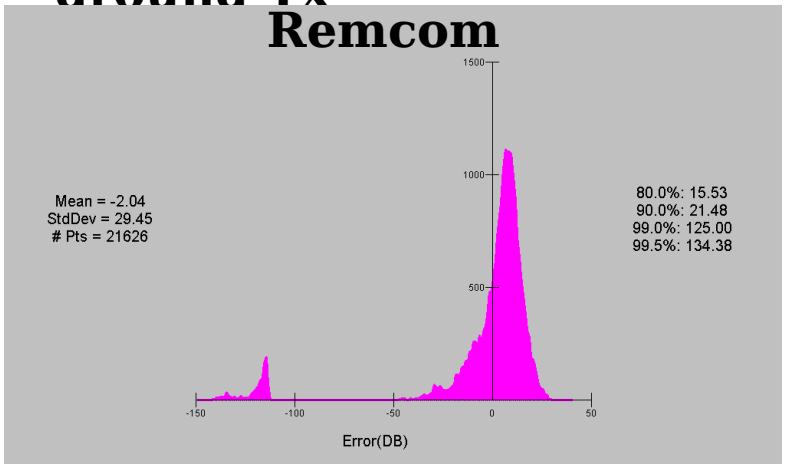

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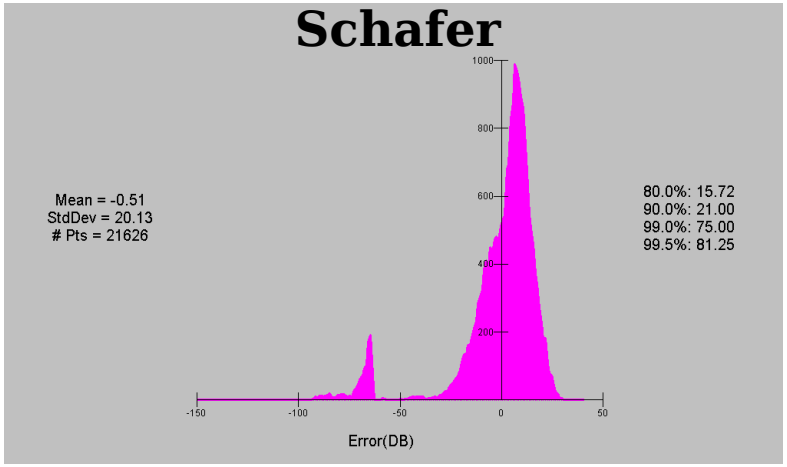

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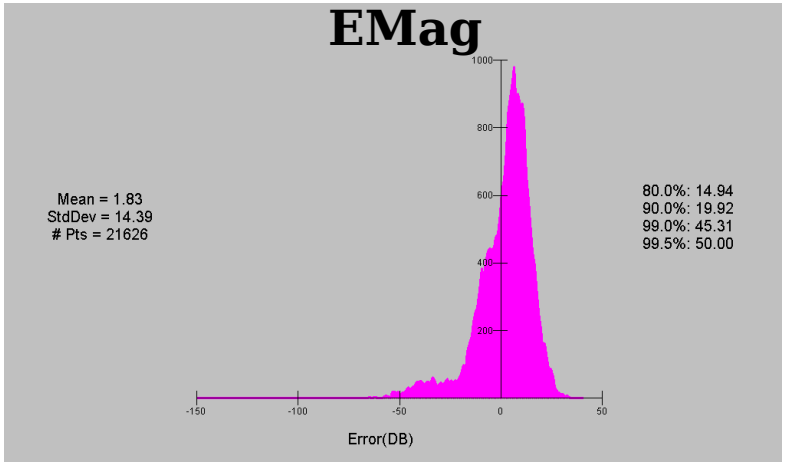

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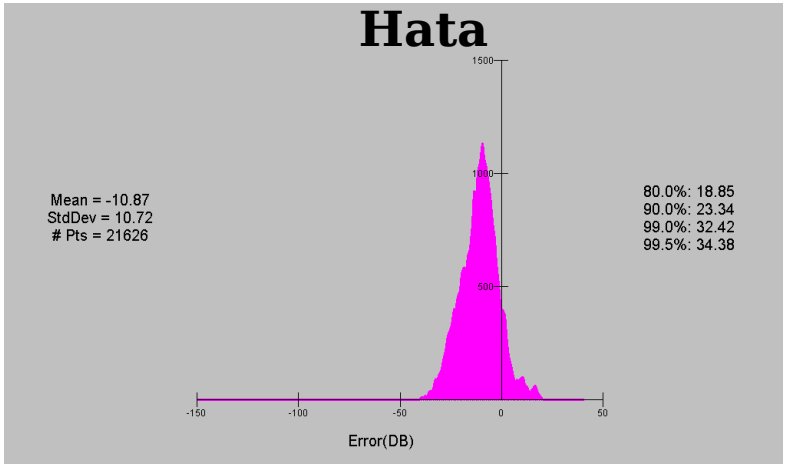

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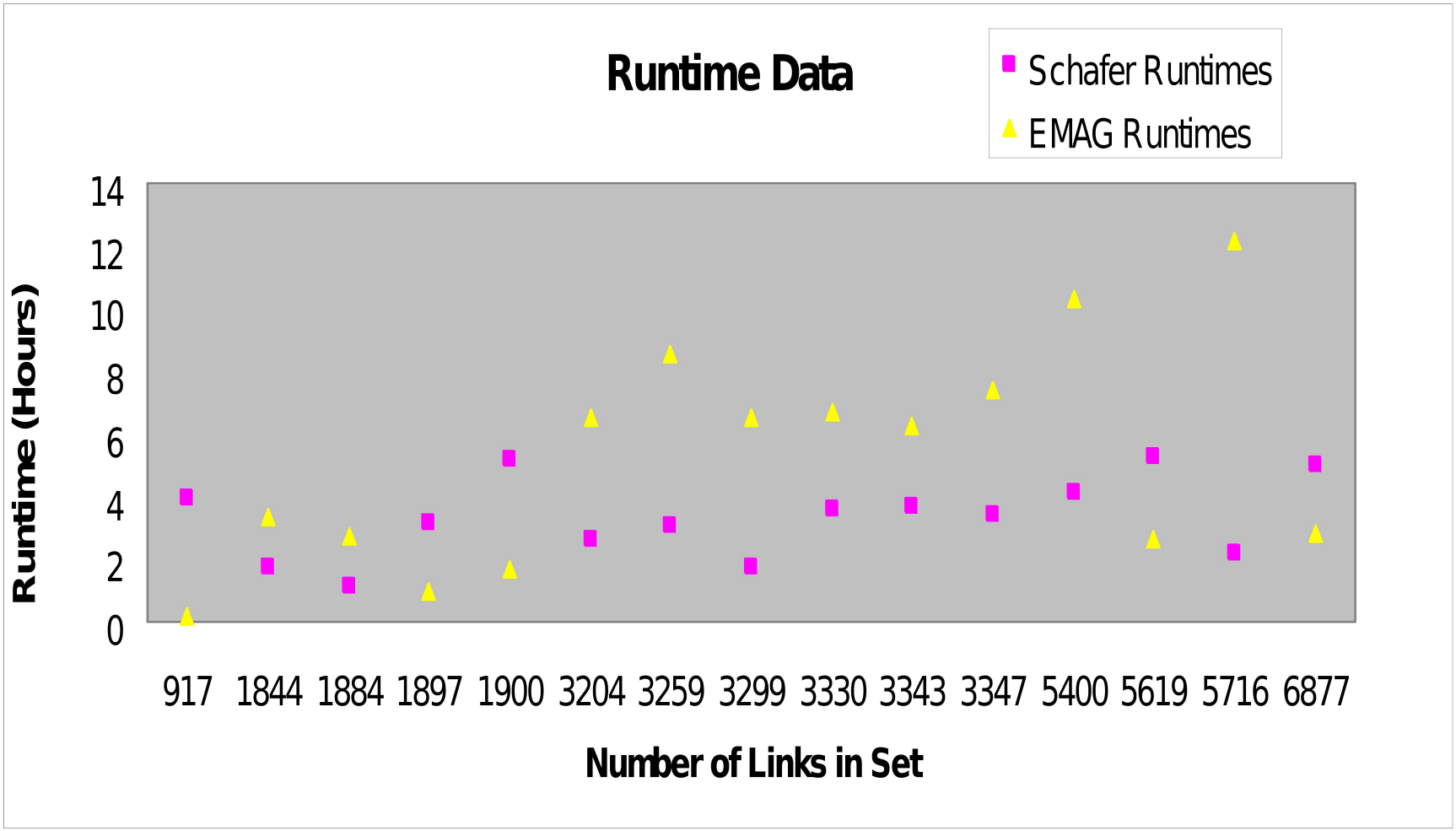

Runs were made on Pentium III machines with Windows NT or Window
833 MHz clock, and 512 – 2 GB RAM

MOUT FACT Proposal Funding Breakdown

AMSAA:

2 analysts at ½ work yr. each for **FY 03 = $160K**
2 analysts at 1/8 work yr. each for **FY 04 = $40 K**

Contract/Data Costs: **(All FY 03)**

Propagation predictions for three urban sites **= $25 K**
Propagation measurements at three sites = **$ 295 K**

-- Labor (contractor and government) **= $235K**
-- Travel (contractor and government) **=$24K**
-- Equipment Costs **= $36K**

Make necessary modifications to model for our envisioned implementation with government performance and force effectiveness models = **$80 K**

Leveraged Funding:

$100 K in labor for work done so far
$15 K for model predictions made thus far

Questions